Optical system for time-keeping ^{87}Rb fountain clock

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Time-keeping ^{87}Rb fountain clocks with excellent long-term frequency stability are becoming increasingly important for UTC(k) generation[1,2].As a laser-cooled atomic clock, the ability of the optical system to operate continuously has a serious impact on the long-term reliable operation of time-keeping ^{87}Rb fountain clocks[3]. This article presents an optical system for the clock that uses a highly reliable fiber laser with a miniaturized optical bench (integrated into a 600mm × 500 mm × 100 mm aluminum box), as shown in Figure 1. The fiber laser is used as a cooling laser source, the ECDL as a repumping laser source, and the bench enables control of the laser frequency and power. Some clever designs in the bench simplify its complexity as well as reduce the number of components, enhancing its long-term operation.

For example, the cooling laser uses MTS spectroscopy as well as digital feedback frequency stabilization, which allows for greater laser frequency detuning during atomic sub-Doppler cooling by applying a larger voltage to the PZT of the fiber laser at digital feedback interval (20 ms) without affecting laser frequency stabilization. Since cooling, detection, and pushing lasers interact with atoms at different times in a clock cycle, frequency detuning of these lasers can be done by sharing an AOM fed with different RF frequencies at different times.

Our time-keeping ^{87}Rb fountain clock based on this optical system now consistently reports data to the BIPM[4] with little human intervention, proving that it meets the long-term operational requirements.

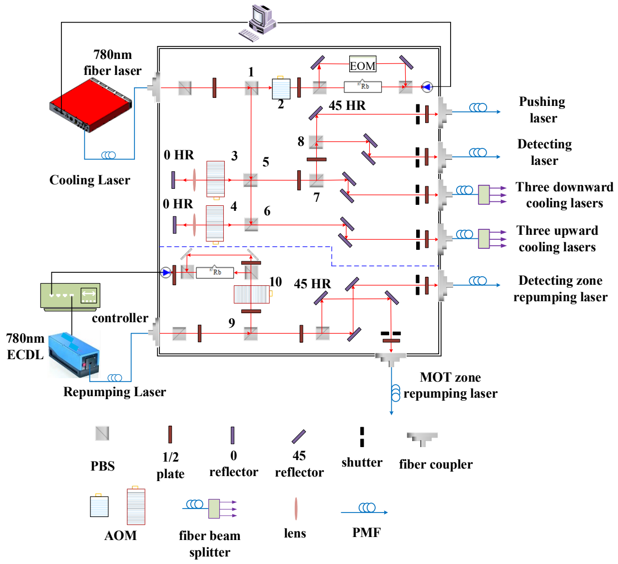

Fig. 1: Schematic diagram of the optical system. The blue dotted lines above and below represent the cooling and pumping laser paths, respectively.

[1] T. G. Akin, “Clock development activities at the U.S. Naval Observatory”, Proc. of 2018 EFTF, p. 17933454, 2018.

[2] K. Y. Pavlenko, “Creation of the first Russian time and frequency standard on a fountain of ultracold Rubidium atoms,” Quantum Electron”, vol. 48, p. 967–972, 2018.

[3] S.Crane, S, “Miniaturized atomic fountain optical table” Proc. of the 2005 IFCS, 2005.

[4] Avaliable at webtai.bipm.org/ftp/pub/tai/other-products/weights/w23.12.